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ABSTRACT

Prediction of clinical performance of medical students in the clerkship phase was made possible in the earliest phase of medical education by a comprehensive and integrative evaluation instrument entitled "Integrative Examination" (INTEX). A proportional sample of the content learned throughout the year is integrated for measuring knowledge, attitudes and skills on various cognitive levels within the clinical context of patient problems. INTEX was found to be a reliable instrument. Also its scores highly correlate with all the constituents of later clinical assessment, creating a valid multitrait-multimethod matrix. The educational implication of an integrative approach to evaluation is discussed. (Author)

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AN EARLY PREDICTION OF CLINICAL PERFORMANCE OF MEDICAL STUDENTS: AN INTEGRATIVE APPROACH TO EVALUATION

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Abstract:

An Early Prediction of Clinical
Performance of Medical Students:
An Integrative Approach to Evaluation

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Prediction of clinical performance of medical students in the clerkship phase was made possible in the earliest phase of medical education by a comprehensive and integrative evaluation instrument entitled "Integrative Examination" (INTEX). A proportional sample of the content learned throughout the year is integrated for measuring knowledge, attitudes and skills on various cognitive levels within the clinical context of patient problems. INTEX was found to be a reliable instrument. Also its scores highly correlate with all the constituents of later clinical assessment, creating a valid multitrait-multimethod matrix. The educational implication of integrative approach to evaluation is discussed.

Early prediction of later students' performance is an issue of obvious importance to medical educators; indeed, it is of concern to any educator. Attempts to address this issue by identifying more predictive admission criteria have had but limited success (Gough, 1967; 1978; Jason, 1972; Benor & Hobfoll, 1981; Hobfoll & Benor; 1981). It may thus be assumed that identification of students with a high failure potential will remain the thrust of the evaluators of students' performance. It is rather obvious that the later this identification occurs, the more painful it is for the individual and uneconomical for the institution.

The search for valid predictors of clinical performance in the pre-clinical phases have been described across a plethora of studies, most of which agree that academic achievements in the early phases are not related to later clinical performance (Wingrad & Williamson, 1973; Rhoads et al., 1974). Several reasons may account for this poor predictive value. The cognitive abilities required by the pre-clinical evaluation instruments stress, more often than not, recollection of disciplinary arranged factual knowledge, in contrast to the integrated nature of the problem-solving tasks expected in the clinical phase (Gjerde, 1968; Neufeld & Barrows, 1974; Elstein et al., 1978). Moreover, the applied nature of the knowledge required by the clinician is different from the theoretical and conceptual knowledge traditionally evaluated by the basic scientists (Jason, 1974; Houts & Hench, 1976). Besides these differences in the cognitive realm, the clinical clerk is called upon to demonstrate both psychomotor skillfulness and affective aptness. These are seldom evaluated in the pre-clinical phases. Finally, there is an apparent shift in students' attitudes during the course of the pre-clinical studies from their initial humanistic "healer" standpoint toward a more scientific approach, based upon the "biomedical model" (Engel, 1977). Such an attitude may be incongruent with the expected clinical behaviour, thus yielding poorer clinical assessments of previously successful students and vice versa (Rhoads et al., 1974)

It is thus suggested that evaluation instruments in the early phases should meet certain requisites in order to be an effective early predictor of later clinical performance. It should assess students' problem-solving skills in an interdisciplinary context, encompassing psychomotor and affective domains as well as cognitive one . Such an instrument, entitled "The integrative examination," has been developed and used in the Faculty of Health Sciences, Ben-Gurion University of the Negev, Israel (BGU) for the past eight years. Its structure, validity and predictive ability are described and discussed.

BACKGROUND

The innovative curriculum and philosophy of BGU have been described elsewhere (Prywes, 1973; 1980; Segall et al., 1978), and so has the integrative nature of this curriculum (Benor, 1982). Hence, the curriculum will only be briefly sketched.

BGU admits high school graduates from both science and non-science tracts to a six year programme. The admission criteria stress personality traits and biographical characteristics rather than scholastic achievements beyond a modest threshold (Antonovsky et al., 1979; Hobfoll et al., 1982). The curriculum encompasses basic and behavioural sciences, public health components and clinical studies from its commencement and throughout the programme. These are integrated within and between disciplines, also enabling an application of the concurrently acquired knowledge to a variety of clinical settings.

The central focus of the basic sciences teaching in the first year is physiology and human ecology, viewed in a wide biological and evolutionary perspective. The programme stresses the observable phenomena and their physical, mathematical and chemical basis, leaving the detailed review of the currently accepted explanations for a later phase. The students participate in a multifaceted clinical programme parallel to the science studies. The natural history of a disease and the life cycle provide the conceptual framework for the clinical studies. The

behavioural sciences teaching is based upon discussing conceptual issues derived from present clinical experiences. The public health component which incorporates epidemiology, quantification, biostatistics and ecology is also integrated into the curricular matrix. The clinical objectives are directly derived from the scientific, behavioural and epidemiological courses, also stressing data collection and simple manipulative skills. Interpersonal communication skills are emphasised from the very beginning, learned through both real-life and simulated situations.

The studies in the second year start with a cluster of closely coordinated courses in cellular and molecular biology, including their application to physiology, immunology, virology and genetics. Introductory courses in all the basic sciences follow, stemming from the general rules of cellular biology. No comprehensive disciplinary coverage is attempted at this phase, but rather an acquisition of a general overview as well as the basic terminology and concepts of each discipline. The parallel clinical studies continue, similarly adherent to behavioural sciences, focused as before on the theme of natural history of disease. Communicative and diagnostic skills are futher developed. The public health programme develops into a research design course, also calling upon conduction of epidemiological field projects. Themes of growth and development, nutrition, immunity and immunisation, infectious diseases and malignant diseases enable integration of basic and behavioural sciences, public health and clinical elements into a series of theme related inter-disciplinary courses.

Years three to five are comprised of integrated organ system modules which alternate with the appropriate clerkships. Each module includes basic and behavioural sciences and public health issues which again are theme rather than disciplinary related. Appropriate clinical skills, including physical diagnosis, are incorporated. The sixth year is devoted to both elective programmes and second rounds in medicine, surgery and primary care clerkships.

THE INSTRUMENT

The integrative examinations (INTEX's) are both comprehensive and integrative evaluation instruments, assessing first and second years students' performance (INTEX 1 and 2 respectively). These provide the only summative evaluation of the corresponding years. (The extensive formative evaluation scheme is beyond the scope of the present communication). Both INTEX's are similar in format although different in content. Each INTEX is comprised of seven subtests, taken over seven sessions of about two to four hours each during five successive days at the end of the corresponding year. They are not time limited, allowing slower students to use more time than the planned 22 hours.

The first three subtests of each INTEX are based on patients' problems evolving along periods of time, including considerations which involve the patient's family and community. The problems are displayed by detailed narrative and by simulated clinical records and reports. The patient problem is followed by about 50 test items, resulting in a total of 150 items over the three problems. These items may be various types of multiple choice, multiple response, matching, completion of tables, short open-ended questions and also not more than 6 percent of essay type questions (10 questions). Some of the questions are multidisciplinary; others are not. Some are related to the patient at a given point of time; others represent generalities, independent of the actual patient's condition. However, both the sequence and the content of the questions are directly related to the described clinical reality. One of the three patient problems is presented by a videotaped interview with a real patient performed by a faculty member. This subtest has no written narrative; however, simulated data and about 50 test items follow the interview.

The content areas of the 150 test items encompasses the entire educational objectives of the corresponding year. Each four hours of scheduled curricular time are represented by one item. The patient problems are composed on the basis of test items provided by the teachers, later scrutinized to better fit the simulated reality.

Each discipline (which may involve more than one course), and each course (which may include more than one discipline) are represented in the INTEX proportionally to their representation in the curricular time, with small predetermined deviations.

Each of the patient problems stresses somewhat different aspects of the curriculum, with a great deal of overlapping, yet all emphasise social, preventative and rehabilitational aspects of patient care alongside with the organic-scientific aspects. A case of an elderly diabetic labourer who suffered from a cerebrovascular accident, for example, raised the issues of cardiovascular physiology; shock and hypertension; interpretation of ECG recordings; aspects of loneliness; the question of rehabilitation (including the issue of institutionalisation and welfare); first aid (including setting priorities); carbohydrate and cholesterol metabolism, cerebral control of locomotion and speech and many others (INTEX 1). A case of breast cancer encompassed the issues of carcinogenesis; immunological and genetic aspects as related to diagnostic and prognostic problems; protein and nucleotide metabolism; epidemiological aspects; psychological and cultural issues related to denial, death, dying, mourning and response to mastectomy; physics of irradiation; principles of xerographic and thermographic techniques; pathological diagnosis of malignancy and its staging; biochemical and subcellular mechanisms of chemotherapy, and many others (INTEX 2).

The videotaped interview provides the basis for the somewhat shorter fourth subtest. In this the examinee is required to write-up the patient's history; to suggest additional clarification questions if appropriate; to identify faults in communication deliberately introduced into the interview, and to assess the interviewing setting. Second year students are also required to create a detailed patient's problem list, using for this purpose additional optional information presented in a latent image print.

In the fifth subtest the student is provided with a list of terms, which may be names of structures, substances or processes. He or she is required to organize these

in a block-diagramme (or a flow chart) format, indicating relationships and feed-back loops. The 24 or 40 items (INTEX 1 and 2 respectively) may describe a homeostatic mechanism (e.g. regulation of body temperature or of blood pressure) or pathophysiological phenomena (e.g. hypertension; carcinogenesis). The terms included are derived from many disciplines, scientific, behavioural, epidemiological and clinical.

The sixth subtest, described and discussed elsewhere (Benor, 1982), requires the student to construct a hypothetical organisam ("a monster") by selecting one option from several in each of 30 'building blocks' representing all the body systems. While performing the task the student should avoid selecting options which are incompatible with each other or with the given environmental conditions. This subtest is included only in INTEX 1, and is replaced by a laboratory skills testing session for the second year students. This latter subtest is a "carousel" time-limited type (Harden & Gleeson, 1979), by which two to four written questions are presented in each of the 14 'stations.' The answering requires an accurate and fast performance of a laboratory procedure (e.g. spectrophotometry; identification of histopathological findings; interpretation of preincubated microbiological plates). Each station or a group of neighbouring stations is related to a patient problem.

The seventh and last subtest is invariably shorter. It includes those test items which were felt to be important for a balanced sampling of the curricular content, yet did not fit into any of the patient problems, This subtest contains about 20 test items, usually in a multiple-choice format, and thus is similar to the better known comprehensive examination.

ORGANISATION AND SCORING

The cognitive level of the 150 test items is strictly preserved, allowing

not more than 30 recollection questions (20 percent) and insisting on at least 50 problem-solving items (33 percent). These higher level questions are not necessarily more difficult, but rather require application of knowledge from more than one course or discipline to solve an unfamiliar problem. The tendency is to keep the same ratio of recall to problem-solving within each discipline. This is sometimes difficult to achieve. Nevertheless, teachers are provided with all the necessary help in order to raise the cognitive level of their questions. Both the final formulation of all the items and their sampling has been done by the first author, subjected to the teachers approval, the latter being exclusively responsible for the itme content. The scoring is mechanized except for the few essay type questions. Sub-scores are computed for each subtest as well as for each course and each discipline over subtests, and are fed back to both teachers and students. The block-diagramme and hypothetic organism subtests are scored in a rather complicated manner described elsewhere, and contribute five percent each to the final score but not to the disciplinary sub-scores. A detailed item anaylsis enables repeated use of good items, not exceeding 45 percent of any new INTEX. The item analysis is also fed back to the teachers.

A minimal passing level is determined before the examination in accordance with Nedelsky's method (Meskauskas, 1976). The student has to meet the minimal level in the INTEX and somewhat lower score in each discipline in order to be promoted, but passing each subtest is not required. Failing students have a second opportunity to take another similarly structured INTEX. In addition, only students who achieved 'satisfactory' assessment by their clinical preceptors during the year may take the INTEX. Those who did not meet this prerequisite have to demonstrate improvement of their clinical skills before being allowed to take the INTEX and have no second opportunity.

VALIDATION METHOD

The study population were the 68 students of the first two BGU classes, enrolled in 1974 and 1975. Four of the students dropped out of the programme because of personal reasons, and an additional six were either held back or expelled because of inadequate performance. The first class (N = 30) graduated in 1981, and the second (N = 28) in 1982.

The criterion variables were the indicators of the students' clinical performance. Seven scores were computed. The first, *observations*, is the average of the assessments of the student-patient encounters. These assessments were performed every four to five weeks throughout the clerkship period by direct observation of these encounters by a clinical instructor who had previously not been in contact with the assessed student. The computed *observations* is a weighted score over clerkships according to the time involvement. The second variable (*ratings*) is an assessment of the students' behaviour during each clerkship on a check-list of 16 parameters, performed by the students' preceptor. The assessed behaviours include interpersonal relationships with patients, staff and peers; persistance, dedication, thoroughness and accuracy; clinical reasoning and judgement; and patients' follow-ups. It does not include any knowledge component. The ratings were done once or twice in each clerkship, usually by two raters. The variable used is also a timewise weighted average across clerkships.

The third variable is related exclusively to knowledge, and is based on similarly weighted averages of the end-of-clerkships written examinations (*clinexams*). Each such examination included 70 to 100 multiple choice questions. In addition 10 patient-management problems (*PMP's*) were given in the pediatric, primary-care and obstetric-gynecology clerkship examinations. The scores obtained on these *PMP's*, also timewise weighted, were the fourth criterion variable used in the validation study. These four variables when considered together, yielded

the fifth criterior variable which is an overall assessment of clinical performance (*clinscore*). It is comprised of *observations* (20 percent); *ratings* (30 percent); *clinexams* and *PMP's* (30 percent); audits of write-ups, evaluations of student's seminars, and assessments of patients' follow-ups after their discharge from the hospital (20 percent for all three).

The next variable is *systems*. This is a timewise weighted average of scores obtained by the stuents on end-of-system written examinations which are the familiar comprehensive multiple-choice examinations of 70 to 100 items each. A timewise weighted average of INTEX 1 and 2, *systems* and *clinscores* yielded an average performance over the 6 year curriculum (*GPA*) which of course is not a variable as it confounds both predictor and criterion variables.

The last criterion variable is a *global* assessment. This is a subjective evaluation of the students independently performed on a single occasion by five key faculty members intimately acquainted with the students. The assessors were aware of some of the students' scores, but none had an opportunity to consult the student files. Moreover, each rater could differently weigh behavioural components, academic achievements, personality, and even extracurricular activities. The *global* variable attempted to assess the extent to which the student approximates a desirable image of the "Beer-Sheva model." This assessment yielded inter-rater reliability of .62 for all possible pairs and .80 for all pairs excluding the class counselors. The variable used is an arithmetic average of the five ratings.

It was assumed that *observations* and *ratings* represent assessment of clinical competencies and that *systems* and *clinexams* reflect cognitive skills. It was further assumed that *clinscopes* and *global* are "mixed" variables, representing an overall assessments of which *global* reflects also the specific institutional objectives and expectations.

RESULTS

Mean scores and standard deviations of the INTEX's and the various criterion variables are presented in Table 1.

Table 1 about here

Split-half correlations between the 150 test-itmes of each INTEX were .78 and .82 respectively ($p < .001$). Table 2 represents Pearson's Product Moment Correlations between the various predictor and criterion variables. It may be noted that INTEX 1 is significantly positively correlated with INTEX 2 ($r = .53$ $p < .001$). It may be further noted that both INTEXs are significantly positively correlated with both "cognitive" variables (*systems*, *clinexams*), "clinical" variables (*ratings*, *observations*), and especially high correlations were obtained with the "mixed" variables (*clinscore*, *global*). Yet the "cognitive" and "clinical" parameters are only moderately intercorrelated, inspite of closer proximity in time of *systems* to clerkships than INTEXs to them. Table 2 also reveals that the second INTEX is a better predictor than the first in all respects as judged by the greater magnitude of the correlation coefficients. The results also suggest that about 22 percent of the variance in the subjective assessment are predicted from INTEX 1 and more than 38 percent from INTEX 2. Naturally, the correlation between *global* and *clinscores*, both evaluated at the same time, are somewhat higher.

Table 2 about here

In order to assess the independent contribution of the various performance predictors to the *clinscore*, a stepwise multiple regression analysis was performed. Only the *global* assessment and INTEX 2, in this order, significantly increased

the explained variance in *clinscores*. INTEX 1 was not considered in this analysis because of its high intercorrelation with INTEX 2.

Table 3 about here

Finally, the various components of the INTEX, assumed to measure specific mental skills, were contrasted with the corresponding evaluations in the clinical phase. The 150 written test-items of the INTEX, assessing knowledge component, were compared with the end-of-clerkship written examinations (*clinexams*). The component of the INTEX assessing communication skills which is based on the videotaped interview as described above, was contrasted with the *ratings* which stress student-patient relationships in real life situations during the clerkships. Similarly, problem-solving skills assessed in INTEX 1 by the Hypothetic Organism Subtest (*HOT*) was compared with *PMP* component in some of the end-of-clerkship examinations. The intercorrelation of the two sets of data yielded a multitrait-multimethod matrix (Campbell & Fiske, 1959) presented in Table 4. If the INTEX is a valid instrument it would be expected that corresponding measures (e.g., cognitive to cognitive) would be more highly correlated than non-corresponding measures (e.g., cognitive to attitudinal). The results indicated a statistically significant "validity diagonal."

Table 4 about here

DISCUSSION

The results indicate that students' achievements during each of their first two years in a six-year curriculum are highly predictive of their later clinical performance. In the present absence of predictive pre-admission criteria, such an early prediction may be of great value.

The results also point out that the Integrative Examination is both a reliable and valid instrument. The reliability is indicated by the split half correlation as well as first-to-second INTEX intercorrelation. The content validity of the examination is obvious due to the described sampling and weighing procedures. Several findings suggest construct validity of the instrument (Cronbach & Meehle, 1967). One is the better predictive value of the seond INTEX as compared with the first, indicating a detection of the improvement of the performance by the instrument. A stronger support is provided by the multitrait-multimethod matrix (Campbell & Fiske, 1959), which indicates consistent high correlations between the various components of the INTEX and other evaluation methods which supposedly measure the same traits. Further, additional construct is suggested by the correlation of the INTEX with both clinical parameters and cognitive ones, indicating the INTEX measures and predicts both. Also the high correspondance with the subjective *global* ratings suggests that the INTEXs predict the extent by which students may approximate the desirabel institutional objectives. However, this last finding should be cautiously perceived, as there is a possibility of a "Hallo Effect."

Several reasons account for the predictive value of the instrument. First, it requires problem-solving ability and thus corresponds to the later clinical requirements. Second, it encompasses both cognitive and attitudinal domains, and even touches upon the psychomotor one (laboratory skills). It thus comes closer to the later clinical expectations. Moreover, even the knowledge component in the integrative examination is presented in a clinical context, which calls upon application of knowledge rather than merely its retention and comphrehension.

The INTEX serves an additional educational objective by demonstrating to the novis students why and how basic and behavioural sciences pertain to the clinical

reality. It thus ehhances an early establishment of a 'biopsychological model' (Engel, 1977) in which patients' problems are viewed in a wide perspective of biological, psychological, social and societal context. This model may be then carried over into the clerkship phase without any undue disonance.

The INTEX is a criterion referenced test in which a wide range of students' competencies are judged against a predetermined standard. Further, the INTEX utilizes a variety of test item formats. This achieves a two-fold goal: First, the error typical to each testing method is reduced (Lipton & Huxham, 1978). Second, it enables differentiation between the various cognitive functions, which include the recollection of the facts; transdisciplinary application of these facts; analytic capability to identify the constituents of a problem; and the skill to synthesise over courses, disciplines and problems. A special emphasis is laid on data organisational and manipulative skills, believed by some authors to be a key to the appropriateness of the later developed clinical reasoning skills (Neufeld & Barrows, 1974). It is thus the case that careful analysis of the test items provides a great amount of information on the student's cognitive abilities. The fact that a 50 item subtest requires four hours or more supports the assumption that the mixed format allows less 'automation' than a uniform format. However, this time requirement for completion of the INTEX is also one of its disadvantages.

The major disadvantage of the INTEX is, however, its required centralistic organisation. This includes the sampling, the balancing between courses, disciplines and cognitive levels of items and their final formulation. It also includes the composition of the patient problems; the computation of minimal pass level; the scoring, and the detailed item analysis. Such central control may, and occasionally does acquit some teachers from being responsible for the students' evaluation. Still another disadvantage is the considerable time

investment required for the preparation, execution and analysis of each INTEX. Nevertheless, the authors agree with Levine (1976) that the evaluation procedures dictate and maintain the curricular structure more than any other single factor. In this sense the required time expenditure becomes a worthwhile investment. Moreover, the construction of an INTEX may and does serve as an on-job training of teachers. This may be more effective than a workshop format because of the vested interest of the teachers.

A few words of caution are felt to be necessary. The presented findings are based on the first two classes of a new and innovative school. As such a tremendous amount of faculty energy was invested into reproducing the ideas inherent in the institutional philosophy. Further years will bear out whether or not this effort accounts for the congruance between the curriculum and the INTEX, and whether this energy investment can be maintained. The present evidence, however, testifies on behalf of the integrative approach to evaluation.

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Table 1

Means and Standard Deviations of

Independent and Dependent Variables

VARIABLE	MEAN (0-100)	STANDARD DEVIATION
INTEX 1	76.02	8.93
INTEX 2	73.53	6.75
SYSTEMS	71.91	7.06
OBSERVATIONS	80.82	9.01
RATINGS	83.62	8.60
CLINEXAMS	78.82	7.56
CLINSCORES	76.60	5.88
GLOBAL	73.32	13.64
GPA	71.07	13.69

Table 2

Pearson's Product Moment Correlation Coefficents Among Independent and Dependent Variables

	INTEX 1	INTEX 2	SYSTEMS	RATINGS	OBSERV.	CLINEXAMS	CLINSCORE	GLOBAL
INTEX 2	.53†							
SYSTEMS	.26§	.54†						
RATINGS	.40§	.45†	.09					
OBSERVATIONS		.46†	.12	.76†				
CLINEXAMS	.39§	.51†	.29§	.46†				
CLINSCORES	.42†	.68†	.62†	.76†	.83†	.64†		
GLOBAL	.47†	.62†	.30§	.48†	.48†	.61†	.71†	
GPA	.57†	.45†	.48†	.52††		.57†	.78†	.56†

† p< .001

§ p< .05

Table 3

Stepwise Multiple Regression of the Various Predictor and Criterion Variables with the Overall Assessment of Clinical Performance (CLINSCORE)

Variable	Step Entered	F to Enter	Significance	Multiple Correlation (R)	Multiple Correlation (r)
GLOBAL	1	43.992	.0001	.711	.711
INTEX 2	2	99.739	.003	.774	.678

Table 4

Multitrait - Multimethod Correlation Matrix
of INTEX 1 vs. Clinical Evaluations

Method		Integrative Examination (year 1)			Clinical Evaluations (years 4-6)		
	Trait	Problem-solving (HOT)*	Knowledge of content (MCQ)	Interpersonal skills (COMM.)**	Problem-solving (PMP's)	Knowledge of content (CLINEXAM's)	Interpersonal skills (RATINGs)
Integrative examination (year 1)	Problem - solving (HOT)	-					
	Knowledge of content (MCQ's)	.06	.78^{+++}				
	Interpersonal skills (COMM.)	.23^{+}	..00	-			
Clinical evaluations (years 4-6)	Problem - solving (PMP's)	.33^{++}	.22	.04	.21		
	Knowledge of content (CLINEXAM's)	.05	.46^{+++}	-.11	.34^{++}	.43	
	Interpersonal skills (RATINGs)	-.03	.10	.13^{+}	.46^{+++}	.31^{++}	.68^{+++}

* Hypothetical Organism subtest
** Communication skills subtest

$^{+}$ $p<.05$
$^{++}$ $p<.01$
$^{+++}$ $p<.001$